National Aeronautics and Space Administration

Ground Facilities and Testing Directorate at NASA Langley

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Offering our customers...

- Quality data with a focus on meeting your schedule and budget
- A suite of co-located facilities covering a full range of speed regimes
- Subject matter experts available to identify and deliver solutions to complex testing and aerospace systems challenges
- Unique test techniques and data visualization tools
- A secure testing environment

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* Facility located in the Research and Technology Directorate

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- Test Articles and Systems
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- Quality Standards and Processes

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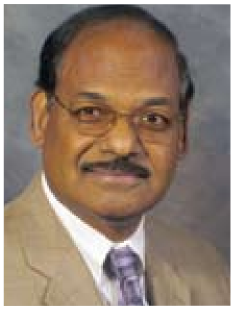
What is the Ground Facilities and Testing Directorate?

A message from the Director of GFTD



NASA is the nation's leading research and development organization in the fields of space and aeronautics. Located in the Hampton Roads area of Southeastern Virginia, Langley Research Center (LaRC) is dedicated to delivering on today's commitments while preparing for tomorrow's opportunities through strategic collaborations with our partners in government, industry, and academia. LaRC's technical contributions over the past nine decades have enabled aerospace systems flight through different speed regimes and atmospheres. The Ground Facilities and Testing Directorate (GFTD) provides unique wind tunnel and structures testing capabilities to support Center commitments to the NASA mission.

The Ground Facilities and Testing Directorate's mission is to develop and deliver high-quality experimental data in a safe and efficient manner. The Directorate's major test facilities include: the renowned National Transonic Facility, versatile subsonic and supersonic wind tunnels, an extensive suite of aerothermodynamics test facilities, the one-of-a-kind Landing and Impact Research Facility, and the Combined Loads Test System. With a diverse, highly skilled and experienced workforce, we conduct classified and unclassified experimental and testing work for our NASA, Department of Defense (DoD), academic and industry partners within the research and development community.

LaRC's AS9100 certified environment provides testing with fabrication, instrumentation, and data support in a one-stop setting. We continually invest to maintain, upgrade and modernize our testing capabilities and methods to meet LaRC, industry, and Agency goals. GFTD also works collaboratively with LaRC's Research and Engineering Directorates. Vital subject matter experts with nationally recognized core competencies in aerosciences, structures, and materials are available to identify and deliver solutions to your complex aerospace systems problems. Our success is measured in terms of customer relations, technical and operational excellence, as we strive to exceed our customer and stakeholder expectations.

While GFTD capabilities support the NASA aeronautics, space exploration and science missions, we also perform other government, industry, and academic customer work competitively. We welcome the opportunity to work with you.

Cordially,

Damodar R. Ambur, Ph.D.
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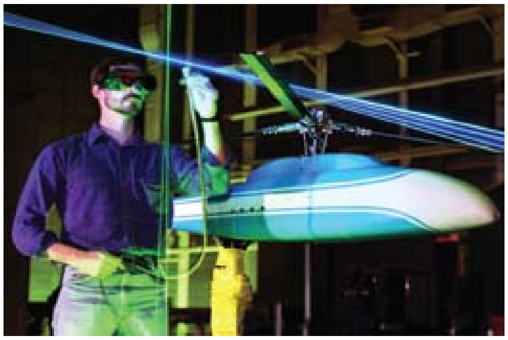
Director, Ground Facilities and Testing Directorate

14x22

14- by 22-foot subsonic tunnel

Subsonic transports, ground vehicles, and military concepts models demonstrate the versatility of the various test section arrangements.

14x22



This versatile low-speed tunnel accommodates fixed- and rotary-wing aircraft, motorsports, and other vehicular tests.

One of our most versatile low-speed facilities, the 14- by 22-Foot Subsonic Tunnel (14x22) is an atmospheric, closed-return tunnel that provides the opportunity to test both powered and unpowered models of various fixed- and rotary-wing configurations. The facility is used to assess aerodynamic performance of civil and military aircraft over a wide range of takeoff, landing, cruise, and high angle-of-attack conditions. It can easily be reconfigured to provide acoustic, tethered free-flight and forced-oscillation testing, motorsports research, aerodynamic material design studies and much more.

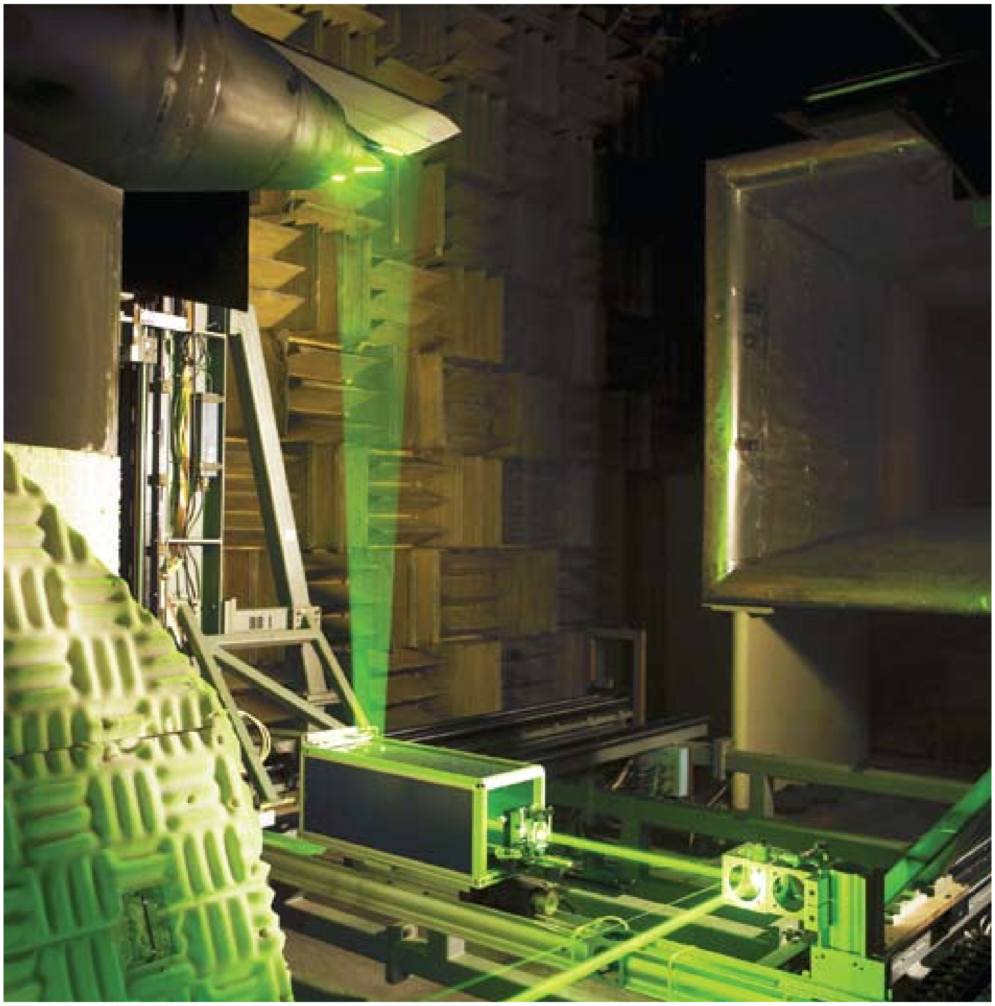
Capabilities
Speed: 348 ft/s (Mach 0 to 0.3)
Reynolds number: 0 to 2.2 x 10^6 per ft
Pressure: Atmospheric
Test gas: Air
Test section size: 14.5' H x 21.75' W x 50' L
Drive power: 12,000 hp
Type: Closed circuit

As an added advantage, the customer has the ability to select various test-section arrangements, from closed (walls, ceiling and floor) to open (floor-only) environments for maximum versatility. The facility has a system of interchangeable model carts that can be selected based on the particular requirements of each customer. A dynamic team of engineers and technicians is prepared to support testing for improved understanding of aircraft aerodynamics. The 14x22 has several model build-up locations in the Model Preparation Area (MPA). A dedicated Rotor Test Cell for rotorcraft model build-up and hover testing is also available in the MPA.

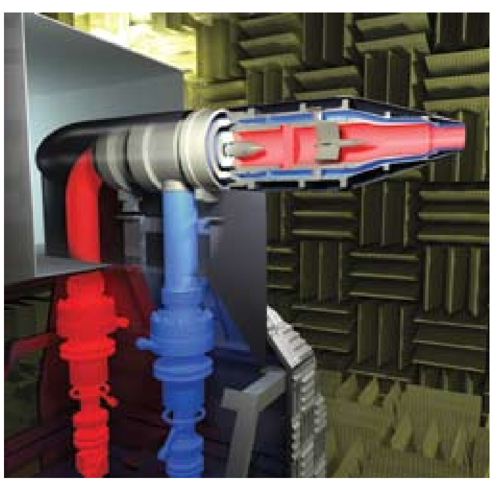
Our clients to date include aircraft manufacturers, defense industry partners, as well as numerous organizations in the Department of Defense (DoD) and other government organizations. Our internal NASA customers have included researchers working space, science, exploration and aeronautics programs in the continuing endeavor to achieve our NASA mission. Universities have also conducted motorsports and other vehicular tests in the 14x22. GFTD offers this capability to provide cost effective and technically proficient wind tunnel testing that often exceeds our customer expectations.

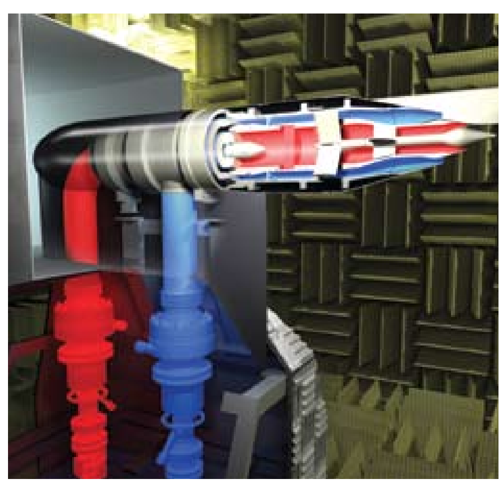
LSAWT

low speed aeroacoustics wind tunnel



Sound generation processes are better understood with combined flow field and acoustic diagnostic techniques, including particle image velocimetry, phased microphone arrays, as well as steady global pressures and temperatures in the LSAWT.





In the JES, supersonic and subsonic configurations (respectively) are shown for both separate and mixed flow turbofan engine cycles, which can be simulated over full throttle lines of current and future commercial and military aircraft.

LSAWT

Realistic flow conditions of commercial and military aircraft engine exhausts are simulated in the anechoic environment of the Low Speed Aeroacoustics Wind Tunnel (LSAWT). Understanding jet noise generation processes, developing noise reduction techniques and investigating complex flow interactions are the focus of the research conducted in this unique facility.

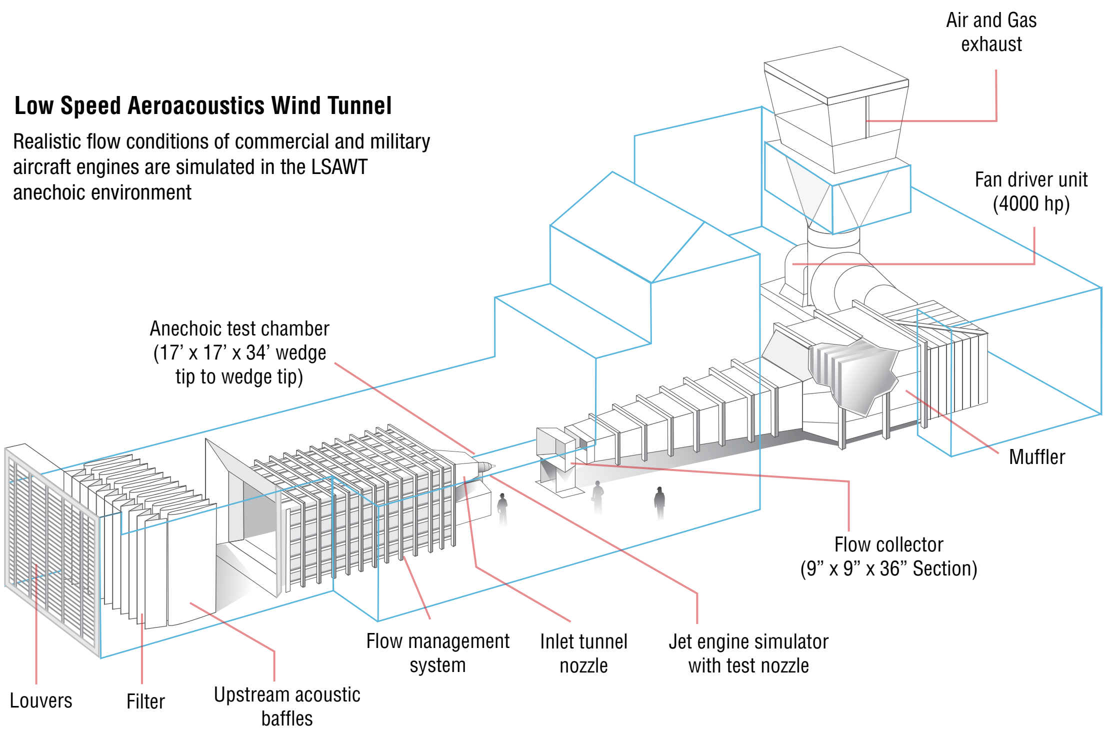
An integral part of the Jet Noise Laboratory (JNL), the LSAWT has been instrumental in comprehensive studies of aeroacoustic improvement technologies for jet noise reduction in both subsonic and supersonic aircraft applications for many years and is particularly well suited for military clients. The test rig has been upgraded to provide enhanced capability in terms of increased temperatures and pressures. Some of the successes have included tests with the DoD, aircraft manufacturers, engine manufacturers and other industry partners.

Capabilities
Free jet speed: 100 to 365 ft/s (Mach numbers from 0.10 to 0.32)
JES nozzle pressure ratios: Up to 12
Free jet test section dimension: 4.5’ x 4.5’
Anechoic test chamber dimensions: 17’ H x 17’ W x 34’ L
JES mass flow: 2 to 20 lbm/s per stream
JES temperatures: Up to 2000 °F

Imbedded in the subsonic flow of the LSAWT is the single/dual flow Jet Engine Simulator (JES), which can simulate separate and mixed flow turbofan engine cycles over full throttle lines of both commercial and military aircraft. The JES provides independent control of both streams at temperatures up to 2000˚F. A series of combined diagnostic techniques in the LSAWT enhance the physical understanding of sound generation processes, flow fields, and acoustics. Test techniques include particle image velocimetry, linear and phased microphone arrays, and steady global pressures and temperatures.

Low Speed Aeroacoustics Wind Tunnel

Realistic flow conditions of commercial and military aircraft engines are simulated in the LSAWT anechoic environment



low speed aeroacoustics wind tunnel

VST

20-foot vertical spin tunnel

The 20-Foot Vertical Spin Tunnel (VST) is the only tunnel in the United States that can conduct dynamically-scaled, free-spin model tests. Nearly every United States Air Force (USAF) and United States Navy (USN) fighter, trainer, and attack aircraft have been tested in the VST. Its unique 20-foot diameter vertical test section has been invaluable in specialized testing for high performance aircraft parachute and ordnance stability, spin chute sizing, spin mode analysis, and rotary balance force and moment data for simulation. Additionally, surface pressure measurements, static force and moment, and forced oscillation tests are supported.

Capabilities
Speed: 0 to 90 ft/s
Reynolds number: 0 to 0.55 x 10^6 per ft
Pressure: Atmospheric
Test gas: Air
Test section size: 25' H x 20' W
Drive power: 400 hp continuous,1300 hp in short bursts
Type: Closed-throat annular return

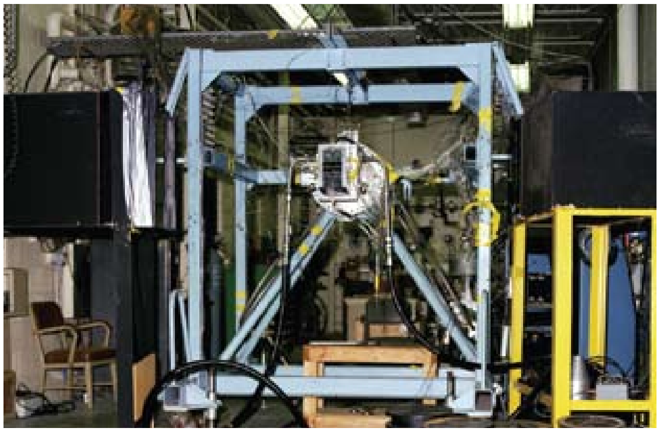
The personnel at the VST are internationally known spin prediction experts on the unique techniques for testing aircraft designs. Their skilled application has resulted in a myriad of lessons-learned from high performance military aircraft that are currently being applied to commercial transports, parachutes, general aviation, as well as spacecraft. Manned and unmanned space vehicles have been tested in the VST, which is ideal for free-falling dynamic stability testing.

The Orion Launch Abort System and Crew Module, X-38, Blended Wing Body aircraft, and the ARES Mars Airplane have been some of the notable Langley test success stories. The knowledgeable VST staff delivers an efficient, integrated research capability in a unique, low-cost environment designed especially for you.

Note: The VST is managed by Langley's Research and Technology Directorate (RTD).
GFTD provides testing support for this facility.

The VST is the only tunnel in the United States that can conduct dynamically scaled, free-spin model tests like the one shown above.

JETF



This facility's dual-flow propulsion simulation system represents a unique feature of this indoor engine/nozzle test facility.

The Jet Exit Test Facility (JETF) is an indoor engine/nozzle test stand which combines high-pressure and high-mass-flow capabilities with multiple-flow air propulsion simulation. Flow rates up to 23 lbm per second are provided by two individually controlled 1800-psia air lines, which supply the test model systems. Supply air is heated to maintain room-temperature conditions at critical model measurement stations.

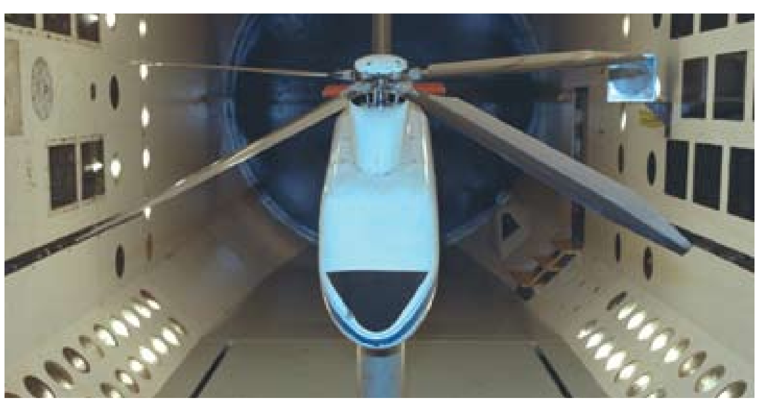
Model support systems available for testing include a dual-flow propulsion simulation system, designed for supply and control of two separate flow fields (a primary or core flow and a secondary flow) and an alternate test rig (a simple plenum chamber that mixes high-pressure air from both sources to supply a single intake for larger scale models).

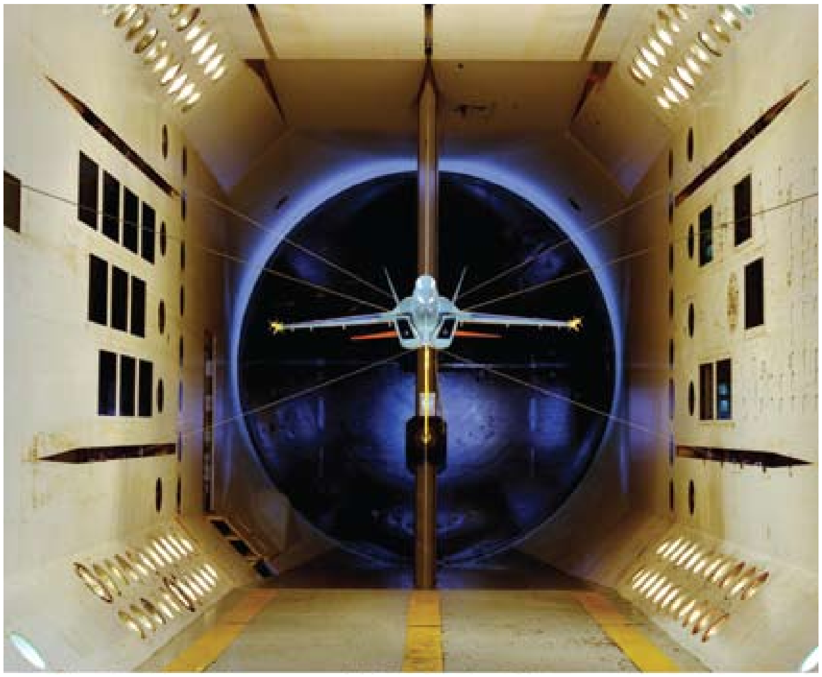
Capabilities
Dual test model system air lines: 2 individually controlled 1800-psia air lines
Flow rates: Up to 23 lbm/s
Mass flow: Less than 1 lbm/s to over 20 lbm/s
Instrumentation: 6-component strain-gage force-and-moment balance, thermocouples, static pressures
Maximum axial force capacity: 1200 lbf
Temperature range: Up to 90 °F

Some of the test techniques include high-accuracy mass flow rate measurements that are available from the Multiple Critical Venturi metering system on each air supply line. Nonintrusive flow-visualization techniques are also available, including shadowgraph density-gradient imaging and surface-oil or paint-flow imaging.

Typical test projects during the last decade have included performance evaluations of advanced exhaust systems, calibration of nozzles and scaled components such as mass-flow plugs for other applications, flow testing of full-scale fan-engine sectors for actuation evaluation, and performance testing of multiple-flow fluidic injection concepts (with core flow at high flow rates and two or more independently-controlled secondary flows at low flow rates) for thrust vectoring, plume control or throat-area control.

A crew launch vehicle model (above) and an advanced rotorcraft design (below) are two concepts demonstrating the versatility of the TDT for testing large aeroelastically-scaled models.





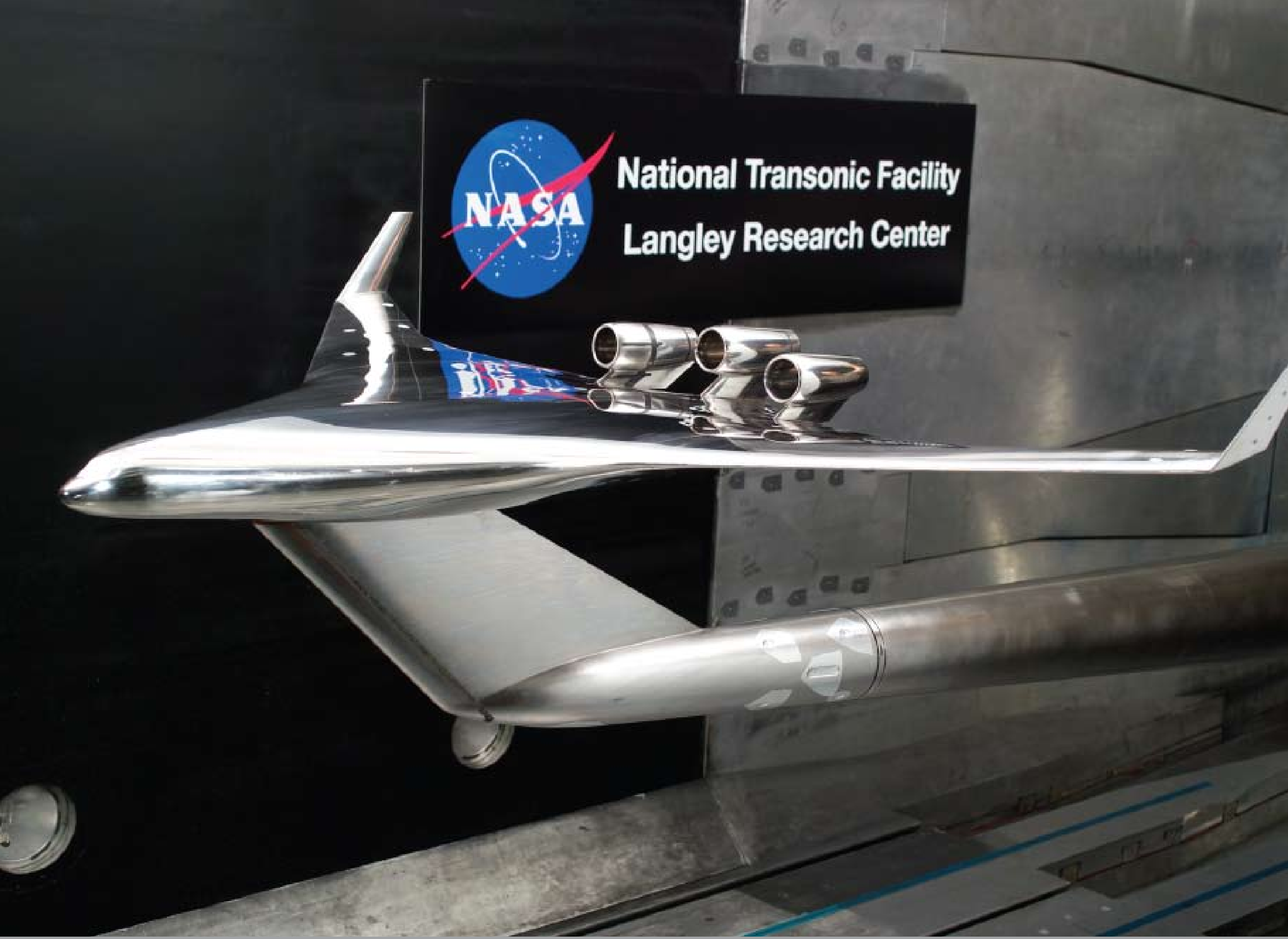
The Transonic Dynamics Tunnel has a rich history of transonic testing in a heavy-gas test medium to achieve higher test densities and Reynolds numbers.

For more than four decades, the Transonic Dynamics Tunnel (TDT) has provided a unique national testing capability for identifying, understanding, and developing solutions for complex aeroelastic and non-aeroelastic phenomena. With a rich history of significant design contributions for a number of commercial transports, launch vehicles, military aircraft, and spacecraft, the TDT is dedicated to providing accurate research data and experimental validation.

One of the distinct advantages of the TDT, particularly for aeroelastic models, is the ability to use a heavy-gas test medium to achieve higher densities compared to testing in air. Higher Reynolds numbers, improved model to full-scale similitude, simplification of scaled model fabrication, reduced tunnel power requirements, and improved safety are just some of the benefits.

Capabilities
Speed: Up to Mach 1.12
Reynolds number: 3.0 to 10.0×10^6 per ft
Pressure: 0.5 psia to atmosphere
Test gas: Air or R-134a
Test section size: 16' H x 16' W x 8' L
Drive power: 30,000 hp
Type: Closed circuit

The TDT is a unique wind tunnel for testing large aeroelastically-scaled models at transonic speeds, and is a vital tool used by NASA, DoD, aircraft industry, and academic researchers in various collaborative partnerships. A dedicated team of engineers, technicians, and staff are available to support you with your aeroelastic testing needs.



A Blended Wing Body (BWB) aircraft model in the NTF which offers the world's highest Reynolds number testing capabilities.

This commercial transport semi-span model is one of the many models tested in the world's largest pressurized, cryogenic wind tunnel.

Military concepts like the Pathfinder II are tested in the nationally renowned NTF.

The world's largest pressurized cryogenic wind tunnel, the National Transonic Facility (NTF), possesses unique capabilities to duplicate actual flight conditions. The NTF supports advanced aerodynamic concept development and assessment, advanced computational fluid dynamics tool validation, and risk reduction for vehicle development.

The NTF provides the highest transonic Reynolds number testing capability in the world, and can use either conventional air at ambient temperatures as the test gas, or gaseous nitrogen (expanded from injecting liquid nitrogen) at temperatures as low as -250 ºF for achieving flight test conditions. With a wide range of customizable instrument and measurement techniques, both full-span and semi-span model testing is supported.

The facility has the unique capability to adjust test conditions to match model size. Independent control of total temperature, pressure, and fan speed allow isolation and study of pure compressibility (Mach) effects, viscous (Reynolds number) effects, and aeroelastic (dynamic pressure) effects. The interior of the pressure shell is thermally insulated to ensure minimal energy consumption, and responsive Mach-number control is achieved with a variable inlet drive system.

Our expert GFTD test team supports a wide variety of notable clients, including large commercial aircraft manufacturers, leading general aviation corporations and NASA's Space Shuttle Program.

Capabilities
Speed: Mach 0.1 to 1.2
Reynolds number: 4 to 145 x 10^6 per ft
Pressure: 15 to 130 psia
Temperature: -250 to -150 ºF
Test gas: Nitrogen or dry air
Test section size: 8.2' H x 8.2' W x 25' L
Drive power: 135,000 hp
Type: Closed Circuit

0.3-M TCT

0.3-meter transonic cryogenic tunnel

An oscillatory blowing airfoil model ready for testing in the 0.3-M TCT.

The 0.3-M TCT features an adaptable test section.

Reynolds numbers up to 100 million per foot can be attained in the cryogenic mode of operation in the 0.3-Meter Transonic Cryogenic Tunnel (0.3-M TCT). Research testing of two-dimensional airfoil sections and other models has been conducted in this highly adaptable research facility in which the ceiling and floor can be streamlined in order to significantly reduce wall effects on the model.

Featuring a test section with a computer-controlled angle-of-attack and traversing wake survey rake systems, the 0.3-M TCT allows the Mach number, pressure, temperature, and adaptive wall shapes to be automatically controlled. Honeycomb and anti-turbulence screens have been added to the settling chamber for improved flow quality.

An electronically scanned pressure measurement system provides high accuracy for steady-state model and circuit pressures at rates up to 20,000 ports per second. Aerodynamic drag is determined using a wake rake attached to a dedicated pressure scanner. Available facility test techniques include focused Schlieren, infrared transition detection, hot films and wires, and laser velocimetry. Additional developmental test techniques include pressure and temperature sensitive paints that permit investigation of boundary-layer transition or separation locations on the models.

Capabilities
Speed: Mach 0.1 to 0.9
Reynolds number: 1 to 100x10^6 per ft
Pressure: 14.7 to 88 psia
Temperature: -320 to 130 ºF
Test gas: Nitrogen or air
Test section size: 13" H x 13" W
Type: Closed circuit

The 0.3-M TCT facility can also be configured for testing in air. Past customers conducting two-dimensional testing include commercial, university, and NASA sponsored research.

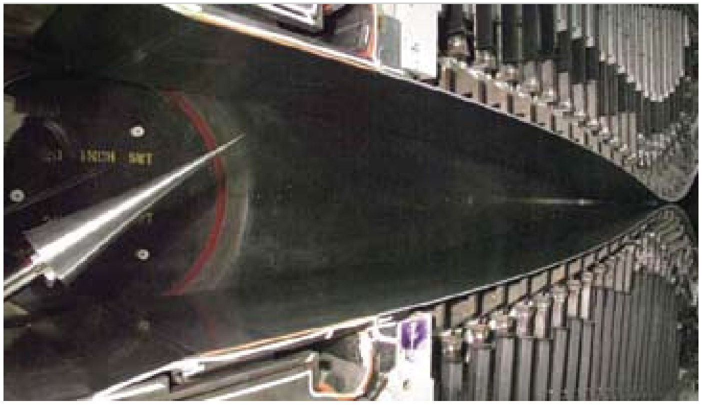
20-In SWT

The 20-Inch Supersonic Wind Tunnel (SWT) is a versatile blow-down facility capable of producing supersonic Mach numbers from 1.6 to 5.0 and subsonic Mach numbers from 0.35 to 0.75. The rectangular test section is 20 inches high and 18 inches wide with optical access on three sides. The tunnel has a unique injection/projection support system for high-speed sting mounted models or models can be mounted on the floor or sidewall. Airfoil testing at subsonic speeds and very low Reynolds numbers is accomplished by using the tunnel's low Mach capability. Depending on conditions, the run times typically range from approximately 30 to 900 seconds. Due to the large capacity vacuum system at LaRC, very low unit Reynolds numbers can be obtained with low stagnation pressures of approximately 0.5 psia at supersonic conditions and 0.2 psia at subsonic conditions. Higher Reynolds numbers are possible at stagnation pressures up to 130 psia for Mach numbers above 2.85. The maximum system mass flow rate of 280 lbm per second limits the maximum Reynolds number for Mach numbers below 2.85.

Capabilities
Mach number: 1.6 to 5.0 (0.35 to 0.75 for airfoils)
Reynolds number: 0.05 to 20 x 10^6 per ft *
Pressure: ~4 to 3,500 psf *
Stagnation pressure: ~0.5 to 130 psia*
Stagnation temperature: 75 to 200 °F *
Mass flow limit: 280 lbm/s*
Maximum model size: 100 in^2 **
Runtime: ~30 to 900 s*
Type: Blow-down

* Ultimate limits are Mach number dependent
** Model size may be further limited by expected unstart loads.

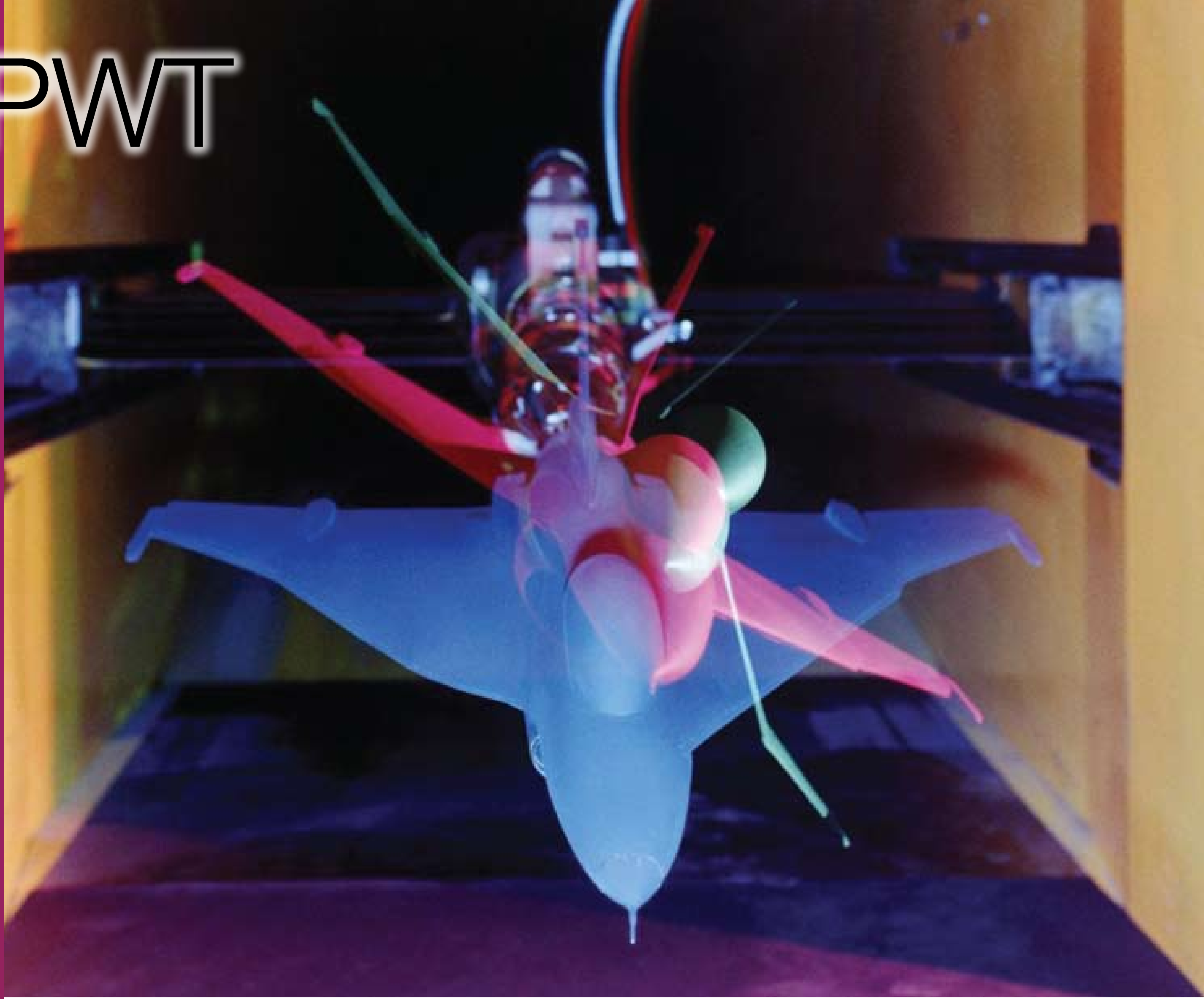
Typical test techniques available in the SWT include pressure (both dynamic and static), pressure sensitive paint, heat transfer, force/moment, and Schlieren. The ability to seed the flow allows a broad array of laser-based measurement techniques to be used. The facility also has a diagonal probe traverse allowing more conventional, but limited off-body measurements. The 24-inch diameter Schlieren system is used for basic visualization at supersonic speeds. For transition detection, hot-wires, films, and sublimating chemicals have been used. Video coverage of the test section and live-Schlieren with video recording are available.



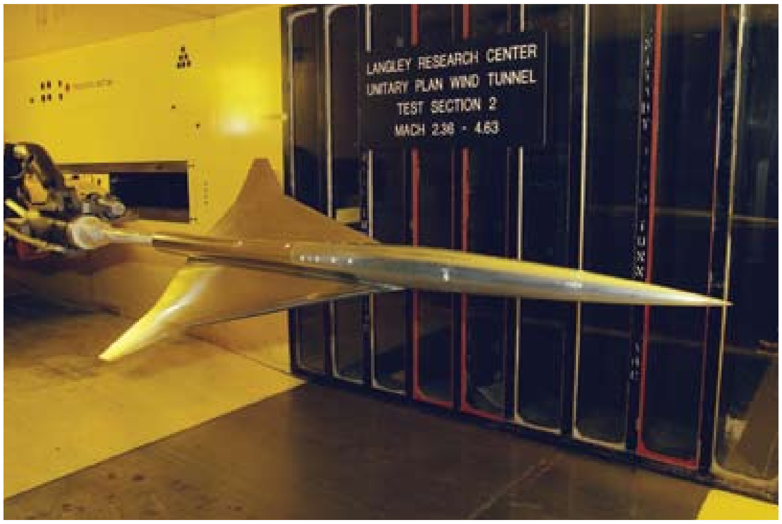
A flared cone model is shown at extreme yaw and pitch angles on the SWT sting mount.

UPWT

4-foot supersonic unitary plan wind tunnel

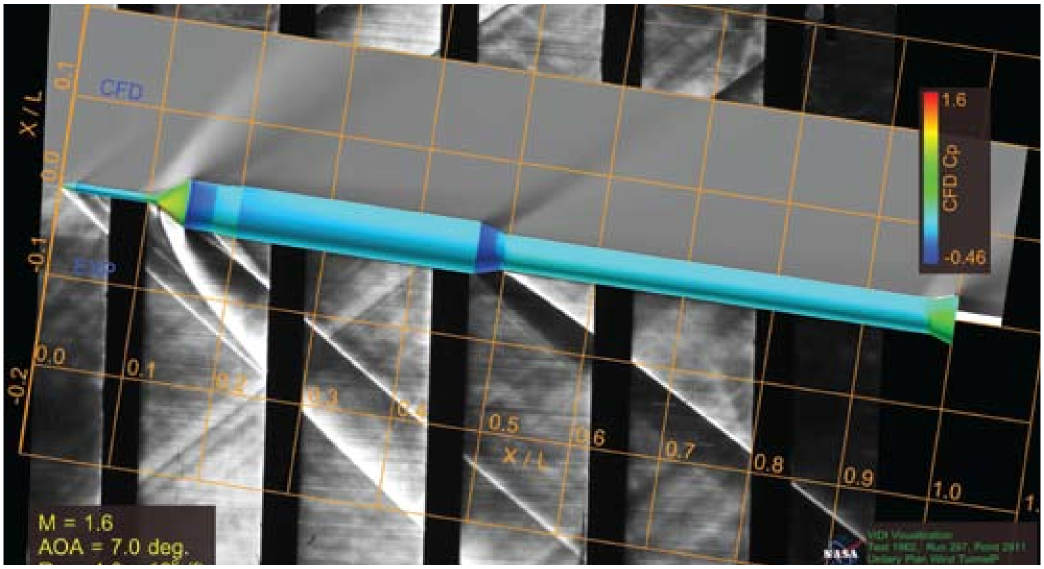


The multiple-exposure image shown above features an F-16 XL wind tunnel model used in support of supersonic laminar flow control testing.



Complex fluid dynamics for this advanced aircraft concept are explored in the UPWT.

UPWT



Real-time, three-dimensional data is shown in the UPWT's interactive, virtual environment, using ViDI test techniques.

The versatile 4-Foot Supersonic Unitary Plan Wind Tunnel (UPWT) boasts a robust set of measurement tools and testing techniques for an enhanced understanding of complex fluid dynamics, as well as applied aerodynamics research. This heavily used supersonic wind tunnel is synergistically matched with other Langley facilities to provide comprehensive testing capability across the speed range from subsonic to hypersonic conditions for developing, assessing, and optimizing advanced aerospace vehicle concepts.

The UPWT has advanced testing capabilities, with an upgraded control system that integrates unique testing options to reduce cycle times. Research customers can gain a unique understanding of their data using the state-of-the-art Virtual Diagnostics Interface Technique (ViDI), a data visualization package designed to display scalar, planar, and three-dimensional data in an interactive, three-dimensional virtual environment in real time.

Capabilities:
Speed: Test Section No. 1, Mach 1.5 to 2.9 Test Section No. 2, Mach 2.3 to 4.6
Reynolds number: 0.5 to 11×10^6 per ft
Pressure: 0 to 10 atm
Total pressure: Test Section No. 1: 56 psia Test Section No. 2: 150 psia
Temperature: 125 to 175 °F w/heat pulse
Test gas: Dry air
Test section size: 4' H x 4' W x 7' L
Drive power: 100,000 hp
Type: Closed Circuit

The existing data measurement processes provide credible methods of quantifying data quality through statistical quality control. Proposed future upgrades are designed to assure continued capability enhancement.

This facility has contributed significantly to major NASA programs such as the Crew Exploration Vehicle (CEV), Crew Launch Vehicle (CLV), Hyper-X (X-43) and X-43C, DARPA, DoD, and other industry partners, who have also used the UPWT in support of their advanced research efforts.

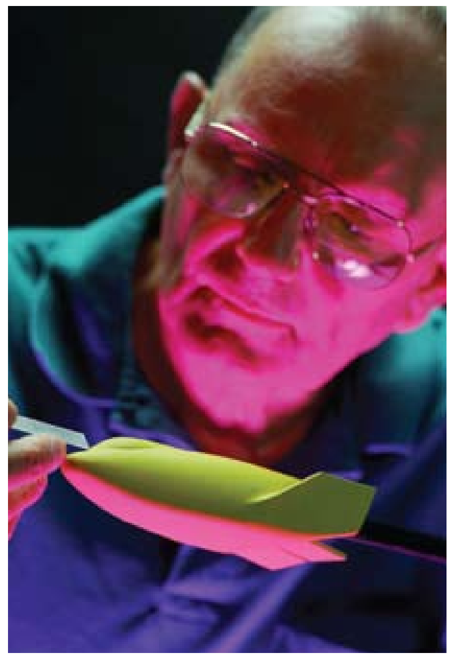
4-foot supersonic unitary plan wind tunnel

LAL

langley aerothermodynamic laboratory

The Langley Aerothermodynamic Laboratory (LAL) consists of four hypersonic blow-down-to-vacuum tunnels that represent 100% of NASA's and over half of the Nation's conventional aerothermodynamic test capability. These economical facilities are relatively small, and ideally suited for fast-paced aerodynamic performance and aero-heating studies aimed at screening, assessing, optimizing, and benchmarking advanced aerospace vehicle concepts and basic fundamental flow physics research.

The development, assessment, and optimization of aerospace vehicles can require testing in the entire family of LAL facilities due to their wide range of hypersonic simulation parameters and unique characteristics. Collectively, this suite of facilities provides a wide range of Mach numbers, Reynolds numbers, and normal shock density ratios.



Close model examination during an aero-heating study.

Over the years the tunnels have been modified and upgraded with hardware components and instrumentation designed to increase capability, reliability, and productivity. Maximum flexibility for our customers is achieved with the commonality of LAL systems and hardware, which usually promotes the use of the same test articles between facilities. The complex uses state-of-the-art tools and test techniques including advanced laser-based nonintrusive flowfield diagnostics and two-color phosphor thermography.

In conjunction with experimental capabilities, extensive expertise resides within the LAL team of researchers, test engineers and technicians, who provide an interactive, flexible, teaming atmosphere for our research partners. Extremely complex, 3-D configurations can be handled in flight regimes from continuum to rarefied, ideal to real gas, and laminar to turbulent flow. This synergistic approach, utilizing both experimental and computational expertise that resides in the LAL, will contribute to the success of your mission.

Since the 1960's the hypersonic tunnels that make up the LAL have provided support to a wide variety of national, international, and industry led test programs. LAL has proven to be indispensable in the development of vehicles ranging from unmanned planetary entry probes and scramjet demonstrators, to manned spaceflight. The LAL has contributed to most major hypersonic vehicle programs from the Apollo, Viking, Space Shuttle Orbiter Development, and Hyper-X, and continues to play a critical role in the Orion Crew Exploration Vehicle, Space Shuttle Operations, and advanced hypersonic technology demonstration vehicles.

A concept model in the 20-inch Mach 6 Air tunnel.

Capabilities

31-Inch Mach 10 Air Tunnel

A hypersonic facility possessing a large temperature driver, that is ideal for heat transfer studies. With its extremely uniform flow quality, it is considered excellent for CFD code calibration experiments as well as aerodynamic performance testing.

Speed: Mach 10
Reynolds number: 0.2 to 2.2 x 10^6 per ft
Dynamic pressure: 0.65 to 2.4 psi
Stagnation pressure: 150 to 1450 psi
Stagnation temperature: 1850 °R
Test gas: Dry air
Shock density ratio: 6.0
Test core size: 14” x 14”
Maximum run time: 120 s

20-Inch Mach 6 Air Tunnel

A versatile, workhorse hypersonic facility used for aerodynamic and aeroheating testing of advanced access to space and planetary vehicles and exploring basic fluid dynamic phenomena including boundary layer transition.

Speed: Mach 6
Reynolds number: 0.5 to 8.0 x 10^6 per ft
Dynamic pressure: 0.51 to 7.6 psi
Stagnation pressure: 30 to 475 psi
Stagnation temperature: 760 to 940 °R
Test gas: Dry air
Shock density ratio: 5.3
Test core size: 12” x 12”
Maximum run time: 900 s

20-Inch Mach 6 CF4 Tunnel

The only operational, conventional hypersonic facility in the US which simulates dissociative real-gas phenomena associated with hypersonic flight. CF4 test media provides a normal shock density ratio of 12 (simulating Mach 13-18 flight) and enables the determination of real-gas effects on vehicle aerodynamics.

Speed: Mach 6 (13 – 18 simulation)
Reynolds number: 0.05 to 0.75 x 10^6 per ft
Dynamic pressure: 0.09 to 1.6 psi
Stagnation pressure: 100 to 2000 psi
Stagnation temperature: 1100 to 1480 °R
Test gas: Tetrafluoromethane (CF4)
Shock density ratio: 11.8
Test core size: 14” diameter
Maximum run time: 30 s

15-Inch Mach 6 High Temp. Air Tunnel

This is an open-jet facility possessing superior optical access and high temperature capability. It is ideally suited for development and application of advanced non-intrusive optical surface and flowfield measurements test techniques.

Speed: Mach 6
Reynolds number: 0.5 to 6.0 x 10^6 per ft
Dynamic pressure: 0.8 to 6.8 psi
Stagnation pressure: 50 to 450 psi
Stagnation temperature: 940 to 1260 °R
Test gas: Dry air
Shock density ratio: 5.3
Test core size: 10” diameter
Maximum run time: 120 s

Visible flow effects are present on the Hyper X (X-43) model, shown above, in the nation's largest hypersonic blow-down facility, the 8ft HTT.

The National Aerospace Plane (NASP) Concept Demonstration Engine (CDE), installed in the 8ft HTT.

8ft HTT

8-foot high temperature tunnel

The nation's largest hypersonic blow-down test facility, the 8-Foot High Temperature Tunnel (8ft HTT) simulates true enthalpy at hypersonic flight conditions for testing advanced, large-scale, flight-weight aerothermal, structural, and propulsion concepts. Flight conditions that would be encountered by hypersonic vehicles in the atmosphere are duplicated with high accuracy in the 8ft HTT facility. Flow conditions are produced by burning methane, air, and liquid oxygen, then expanding the combustion products through any one of several nozzles into the test section, producing the test stream. Testing capability for Mach numbers of 3, 4, 5, and 7 are supported in this unique testing environment.

Very large scale structural or thermal protection system models (5x9 ft), hypersonic engine testing, and flight qualification testing is supported in the facility test section.

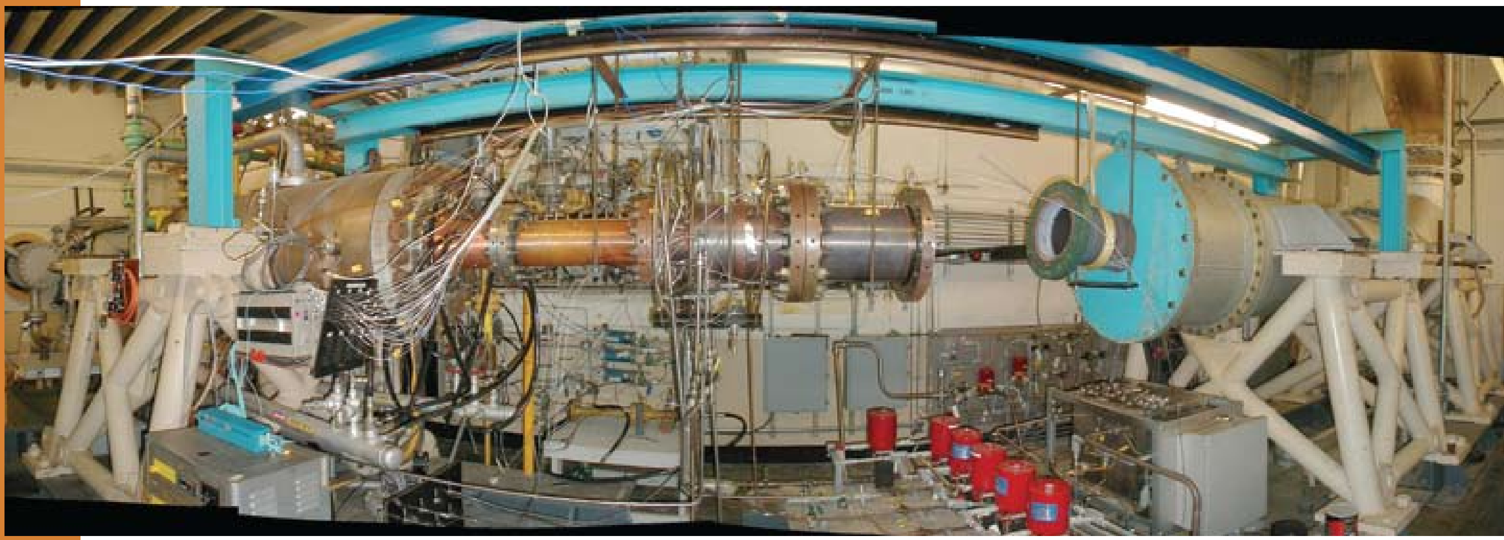
An experienced hypersonic test team is trained to handle numerous test support systems that are available to meet a wide variety of test requirements. Unlimited optical access for photography and video systems is provided.

The facility has been heavily used for testing engines such as the National Aerospace Plane (NASP) Concept Demonstration Engine, the Office of Naval Research HyFly Dual Combustor Ramjet, and the Air Force Research Laboratory SJX61-1 and SJX61-2 engines. It has supported different programs and agencies such as the Hyper-X Program, U.S. Missile Defense Agency, Japanese Defense Agency, NASA Next Generation Launch Transportation (NGLT) program, and NASA program for the Advancement of Inflatable Decelerators for Atmospheric Entry.

Capabilities:
Speed: Mach 3, 4, 5, and 7
Reynolds number: 0.44 to 5.09 x 10^6 per ft (Mach dependent)
Altitude range: 50,000-120,000 ft
Plenum stagnation temperature: 900 to 3500 °F (Mach dependent)
Plenum stagnation pressure: • 50 to 2000 psia with oxygen enrichment • 50 to 4000 psia with no oxygen enrichment (for thermal protection system testing)
Test section size: 8' diameter x 12' L
Nozzle exit dimension: 96" diameter

SCRAMJET

supersonic combustion ramjet



A liquid-fueled Ramjet combustor model installed in the unique Direct-Connect Supersonic Combustion Test Facility.

For over four decades, NASA Langley has conducted a wide spectrum of experimental supersonic combustion research related to hypersonic air-breathing propulsion. The Supersonic Combustion Ramjet (Scramjet) Test Complex is a leading-edge ground test capability comprised of several distinct facilities. The complex includes a direct-connect combustor test facility, two small-scale complete engine test facilities, the Mach 4 Blow-Down Facility, and the 8-Foot High Temperature Tunnel, a large-scale complete engine test facility (see previous page).

Langley has provided significant technological advantages in various research applications in the government and military sectors as well as private industry. Progressive research has resulted in the optimization of scramjet combustor design methodologies, ground test techniques, and data analysis procedures.

Recent collaborative successes have been with the NASA Hypersonics Program, USAF, NASA Glenn Research Center (GRC), premier engine manufacturers and commercial airline manufacturers. Our research staff provides a high level of expertise and an experienced knowledge base for our customers.

A model technician inspects the model for safety in the Arc-Heated Scramjet Test Facility.

Capabilities

Combustion-Heated Scramjet Test Facility

Simulated flight Mach number: 3.5 to 6

Reynolds number: 1.0 to 6.8x10^6 per ft

Nozzle exit Mach number: 3.5 and 4.7

Nozzle exit area: 13.26” x 13.26”

Test gas: hydrogen-air combustion products with oxygen replenishment

Total pressure: 50 to 500 psia

Total temperature: 1300 to 3000 °R

Arc-Heated Scramjet Test Facility

Simulated flight Mach number: 4.7 to 8

Reynolds number: 0.035 to 2.2x10^6 per ft

Nozzle exit area for Mach number of 4.7: 11.17” x 11.17”

Nozzle exit area for Mach number of 6: 10.89” x 10.89”

Test gas: Dry air

Total pressure: 675 psia

Total temperature: 2000 to 5200 °R

Mach 4 Blow-Down Facility

Simulated flight Mach number: 4

Reynolds number: 20x10^6 per ft

Nozzle exit Mach number: 4

Nozzle exit Area: 9.0” x 9.0”

Test gas: Dry air

Total pressure: 200 psia

Total temperature: 540 °R

Direct-Connect Supersonic Combustion Test Facility

Simulated flight Mach number: 4 to 7.5

Reynolds number: 2 to 8x10^6 per ft

Nozzle exit area for Mach number of 2.0: 1.52” x 3.46”

Nozzle exit area for Mach number of 2.7: 1.50” x 6.69”

Test gas: hydrogen-air combustion products with oxygen replenishment

Total pressure: 115 to 500 psia

Total temperature: 1600 to 3800 °R

COLTS

combined loads test system

The COLTS facility was selected to test out the Composite Crew Module because of its volume and pressure capabilities and its control and systems aquisition.

COLTS is a unique testing facility used to verify large structural concepts.

The Combined Loads Test System (COLTS) is a unique structural testing complex in which large curved panels and cylindrical shell structures have been tested for the past several years. Aircraft fuselage section components of commercial transports and space structures are subjected to combined loading conditions that simulate realistic flight load conditions.

The COLTS combined loads test machine enables researchers to select a unique set of requirements for their real-time display and test data acquisition. The data systems have been designed with an open architecture and connectivity that support both data acquisition and management functions, in order to accommodate the complex nature of the mechanical and thermal loads on a particular test article.

Capabilities
Combined mechanical, internal pressure and thermal loads
Mechanical and pressure loading: cyclic
Curved panels: Up to 10' L and 8' W using D-Box test fixture
Cylinders: Up to 15' in diameter and 45' L

The competent staff at the COLTS testing complex are available to provide experimental verification of structures technology concepts for our research customers.

ALDF

aircraft landing dynamics facility

Test tires may not survive long when the ALDF's 108,000-pound test carriage hurtles down the half-mile track at 220 knots.

The Aircraft Landing Dynamics Facility (ALDF) has a unique testing capability that provides economical and efficient testing of aircraft wheels, tires, brakes and advanced landing systems. It is used to evaluate tire hydroplaning phenomena, effectiveness of pavement grooving, and friction and wear characteristics of aircraft and ground vehicle tires. Research performed at this facility has led to a number of improvements in landing gear components, aircraft tires, runway and highway surfaces.

ALDF test runs are high speed. In less than two seconds, thousands of gallons of water and pressurized air propel a 54-ton steel carriage mounted on rails to race car velocity. It is stopped by a series of arresting cables similar to those used to stop fighter jets on aircraft carriers. Industry tire and brake manufacturers test prototypes in this facility before entering into mass production. A large commercial aircraft manufacturer evaluated radial ply tires and conventional bias ply tires for use on its wide-bodied passenger jets at ALDF.

Capabilities
Carriage speed: 220 knots
Carriage weight: 108,000 lbs
Track length: 2,800 ft
Max acceleration: 20g's
Open bay size: 20' x 40'
Max vertical velocity of test article: 20 ft/s
Max vertical load of test article: 65,000 lbs

NASA Langley's hydroplane researchers have used ALDF to increase aircraft tire traction and decrease braking distances on water-covered runways. Research showed that the best way to enable aircraft tires to get more grip was to cut thin 'grooves' into the runway pavement to let the excess water squeeze out from beneath the tires. This technology was very effective and 'safety grooving' has been adopted for use on hundreds of airport runways and highways around the world. Most U.S. states have grooved all or a portion of their highway system, as well as some pedestrian walkways, ramps, steps, swimming pool decks and playgrounds.

LandIR

landing and impact research

Landing tests being conducted at Langley's Landing and Impact Research Facility (LandIR) on the Orion Crew Exploration Vehicle.

Crash-worthiness testing has been one of the LandIR's critical contributions to today's aircraft.

LandIR

A national historical landmark, the Landing and Impact Research Facility (LandIR) vehicle structural testing complex, better known as the "gantry", was first built in 1963 to train astronauts to land on the moon. Since that time the 240-foot high, 400-foot long, 265-foot wide, A-frame steel structure has been used to provide crucial research test data on the crashworthiness of General Aviation (GA), commercial aircraft and rotorcraft. Notable successful research programs include: full-scale crash tests of GA aircraft and helicopters; system qualification tests of Army helicopters; vertical drop tests for a large commercial aircraft manufacturer; as well as composite fuselage section and drop tests of the F-111 crew escape module.

Capabilities
A-frame, steel structure: 240' H x 265' W x 400' L
Weight support capacity: 64,000 lbs
Vertical drop tower: 72' H
Pendulum swing capacity: 200'
Resultant velocity: Over 70 mph

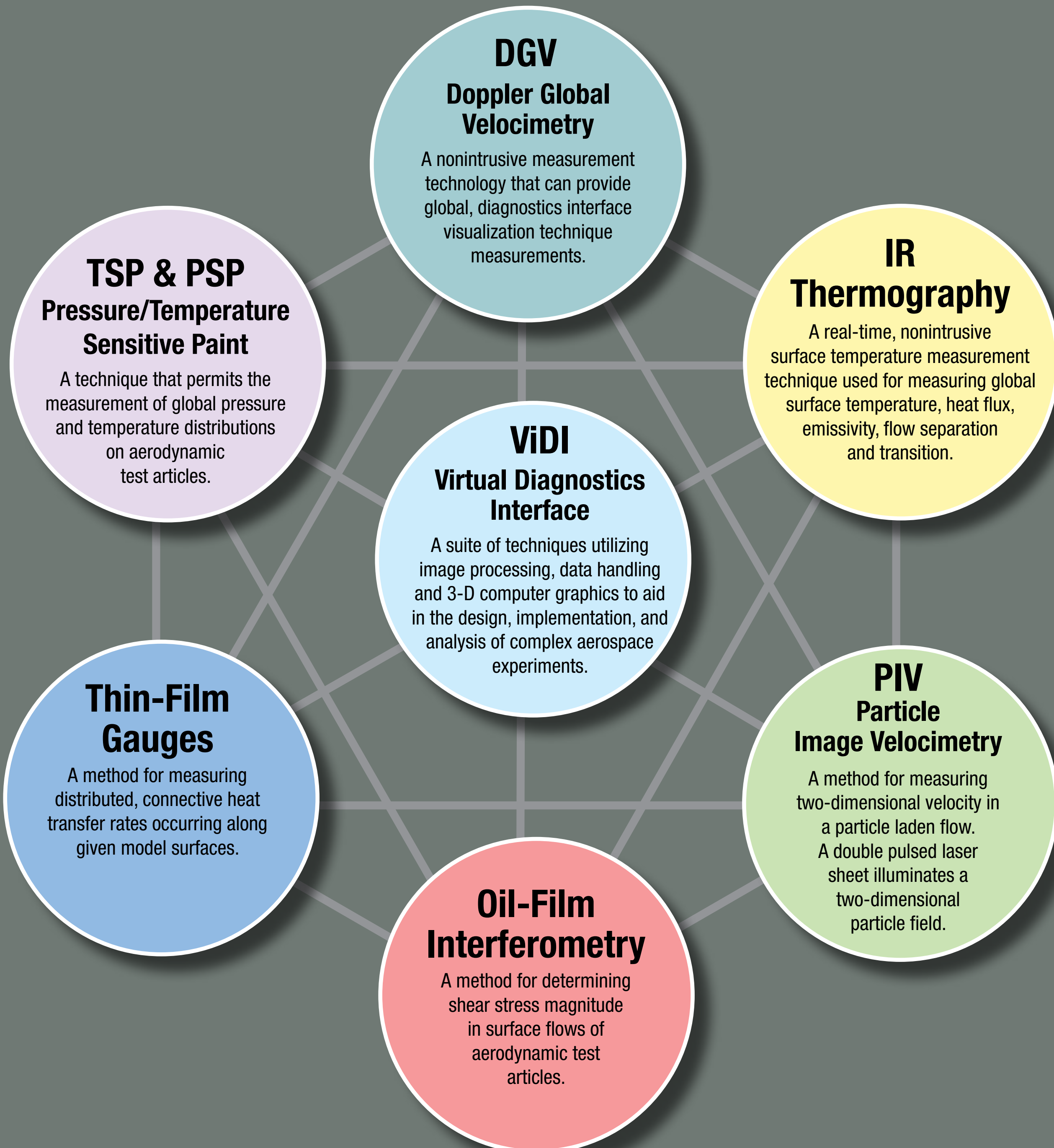
The complex has been used recently for space exploration research testing, with the latest drop tests for NASA's, Orion Crew Exploration Vehicle. The LandIR is enabling research testing to determine the optimal landing alternative for NASA's first, manned dry landing on Earth. Additionally, these tests enable crucial understanding of lunar landings and vehicle re-entry in preparation for Orion's journey to the International Space Station, the moon, and beyond.

The flexible LandIR complex can be configured to perform various types of tests including retro-rocket landing systems and scale-model water landing tests using a four-foot-deep circular pool. Many tests have been conducted at night to recreate lighting conditions on the moon.

NASA Langley's LandIR complex is serving a vital role in the development of aeronautical and space exploration systems, and is poised for significant contributions in the future.

Several airbag concept designs for the (CEV) have been tested at this easily reconfigurable complex.

A SAMPLE OF AVAILABLE TEST TECHNIQUES



The information presented above represents a sample of available test techniques that can be applied in GFTD facilities. These techniques are complimented by Langley's team of experienced research, operations, and systems engineering personnel.

For additional information on specific techniques, please contact the Chief Engineer for Advanced Capabilities at the GFTD Main Office: (757) 864-6885 or send an e-mail to larc-dl-gftd@mail.nasa.gov

Drag-reduction tests being conducted on a supersonic transport design concept in one of the Ground Facility Testing Directorate's tunnels.

Doing Business with GFTD

The Ground Facilities and Testing Directorate at NASA Langley Research Center offers and expansive array of test and evaluation capabilities and has been partnering with numerous organizations from government, private industry, and academia to provide value-added research and development support. Our experienced and knowledgeable team provides the best testing solutions with high quality test data.

For additional information on how GFTD capabilities can meet your testing needs, please contact the GFTD Chief Engineer for Testing Operations Excellence at (757) 864-6885
or send an e-mail to larc-dl-gftd@mail.nasa.gov

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